Agroforestry Adoption Potential in Cape Verde

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In the Água de Gato Watershed on the island of Santiago (Cape Verde Islands), 51 farmers were surveyed for their willingness to plant trees on their farms for various purposes. Farmer and farm demographic data were also collected to determine those characteristics associated with willingness to plant. Ninety-two percent of the farmers surveyed expressed a willingness to incorporate more trees into their farming practices, and the remainder indicated they were unsure. Linear discriminant analysis was used to relate the demographic variables to willingness groups to plant trees for fruit, fuelwood and shade. Discriminating variables were found to include farmer age, gender, marital status, family size, and farm area (owned, rented or farmed in partnership). Interactions were also observed between the various use categories. For example, farmers who were willing to plant trees for fuel were also more willing to plant trees for shade, and farmers who were willing to plant trees for fruit were unwilling to plant trees for shade. Discriminant analysis models were developed that accounted for correct classifications ranging from 63% to 88%, and averaging 75%.

Keywords: Forestry extension, trees on farms, Cape Verde, sustainable agriculture

INTRODUCTION

Tree planting and indigenous agroforestry systems are widespread in Africa, owing their origin in some part to tree planting projects during colonial times, and later to extension projects tied to development programs (Franzel and Scherr 2002). While farmers may be quick to recognise the many benefits of incorporating trees into their agricultural landscape, many barriers remain to the development of agroforestry as a land-use system. For example, Johnson and Delgado (2003) found that in the Republic of Cape Verde, constraints to agroforestry adoption and their frequency of citation by farmers included: lack of a line of credit (100%), land and space availability (94%), availability of seedlings (88%), need for incentives (84%), land

and water availability for nursery implementation (61%), uncertainty of land and tree tenure (55%), laws (20%), and lack of technical support (18%). There are currently no commercial nurseries in the watershed, so farmers are concerned about access to a supply of seedlings at an affordable cost and with the species they desire. Likewise, those farmers who rent land are concerned about their ability to harvest trees or fruit in the future. Uncertainty over tenure, and the possibility that laws or regulations may pass that would not favour their land access, serve as significant constraints. Despite these constraints, 92% of farmers surveyed looked favourably on planting more trees on their farms.

Franzel *et al.* (2002) summarised the evolution of agroforestry research and extension over the past 20 years, with an eye toward improving the adoption of agroforestry technologies by willing farmers. The key to this evolution has been participatory on-farm research, so that the research can be tailored to the needs of the farmer, and results can be observed first-hand. But prior to this active part of the process comes an awareness step. Farmers must be open to the concept of planting trees, often on highly space-confined farms, with limited water and nutrients. In the logic model of extension, awareness is followed by advances in knowledge and skills, which leads to changes in practices.

Agroforestry is a hybrid land-use system (Huxley 1982), and its adoption success hinges on its ability to meet the user's end needs, e.g. increased economic returns (Thatcher *et al.* 1997, Mary *et al.* 1999), reduced labour (Ketterings *et al.* 1999), taking advantage of existing knowledge and capabilities (Den Biggelar and Gold 1995, Walker *et al.* 1995, Thapa *et al.* 1995), and positive environmental benefits (King 1979, Swinkels *et al.* 2002). Franzel *et al.* (2002) developed a framework for assessing the adoption potential of agroforestry practices, based on six key factors, namely biophysical performance, profitability, feasibility and acceptability, boundary conditions, lessons for effective dissemination involving extension and policies, and feedback to research and extension.

In order to promote farmer adoption of new practices, questions such as the following must be adequately addressed:

1. Will the agroforestry practice result in higher yields or environmental benefits?
2. Is the practice sustainable?
3. Is the practice profitable in comparison to alternatives?
4. Do farmers have the required information and resources?
5. Under what conditions will the practice be profitable, feasible and acceptable?
6. What types of extension services do farmers require to support the practice?
7. Are existing policies and regulations conducive to the practice?
8. Can farmers readily modify the practice to suit their needs?

The present study was undertaken in the Água de Gato Watershed in the Republic of Cape Verde. During 1994, the US Agency for International Development (USAID) initiated a project under the Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program (SANREM CRSP). One of the objectives of the project was to support research that would assist in the development of sustainable farming systems. USAID had already begun watershed-level research in the Água de Gato Watershed, located on the southernmost island in Cape Verde (Santiago), so this seemed a logical location to continue the sustainable

farming project. During 1994, project scientists, in cooperation with the Cape Verde National Institute for Agricultural Research and Development (INIDA), conducted a Participatory Landscape/Lifescape Appraisal (PLLA) with local farmers. From this PLLA, a host of research objectives were identified, including the development of agroforestry systems that would enhance the diversity of products on farms in the watershed.

Based on general information from the PLLA, it was determined that a more detailed survey of farmers in the watershed was necessary to assess the opportunities and possible constraints for agroforestry, as well as the likely adoption potential of acceptable agroforestry practices. In essence, this project was the exploratory phase, assessing awareness of agroforestry and developing the necessary background information to formulate a project in which agroforestry practices could be developed, tested and refined. The farmer perspectives on agroforestry opportunities and constraints were published previously (Johnson and Delgado 2003). This paper focuses on further analysis of the willingness to plant trees data, particularly with regard to the relationship between farmer characteristics and the willingness to plant trees for the three primary purposes of fuelwood, fruit and shade.

RESEARCH METHOD

Location and Characteristics of the Study Area

The 350-ha Água de Gato Watershed in southern Santiago consists of steep terrain, with elevations ranging from 350 to 750 m above sea level. The volcanic soils are only weakly developed, and are of basaltic origin with feldspathic mineralogy. The soils are highly erodible, rich in mineral nutrients, but low in nitrogen and organic matter. Climatically, the watershed is situated in a transition between the sub-humid and semi-arid zones. The annual precipitation of 250 to 600 mm falls mainly during July to September.

The Água de Gato Watershed is classified as a herbaceous steppe, and has few shrubs or trees. Most trees are fruit trees, with mango (*Mangifera indica*) the most common. Other common trees include African mahogany (*Khaya senegalensis*), silk cotton tree (*Ceiba pentandra*), mesquite (*Prosopis juliflora*), eucalyptus (*Eucalyptus camaldulensis*), and umbrella mulga (*Acacia holosericea*). Wood and other organic matter are routinely burned for fuel by inhabitants of the watershed, so there is a great deal of pressure on the limited tree resource.

Both irrigated and rainfed agriculture are practiced in the watershed. Irrigated agriculture is confined to the best soils on the bottomlands, while rainfed agriculture is practiced on the side slopes and ridges. Two agroforestry systems are in use in the watershed: home gardens and multistorey tree gardens. Shifting cultivation is sometimes used on steep hillsides, the land being cultivated for a few years until soil fertility fails due to erosion and loss of nutrients, and then left fallow for a few years before being cultivated again. Sometimes the erosion is so severe that agricultural use is abandoned.

Vera Cruz *et al.* (1994) reported the Água de Gato Watershed as consisting of 957 inhabitants in 177 families. Agriculture and animal husbandry are the principal occupations, primarily on a subsistence level. Some inhabitants are employed by a federal agency that conducts conservation and rural development projects, including

construction of roads, schools, irrigation channels, hillside terraces and check dams. The Catholic Church owns about half the land in the watershed, which is mostly rented back to the farmers. Individual farmers may work their own land, rent land out to others, work land rented from others, or sharecrop with other farmers. Under the sharecrop arrangement, the farmer works the land and provides a portion of the harvest to the owner, usually on a 50:50 basis. In this case, the farmer provides the labour and other costs of production, and receives half of the crop.

Survey Method
A questionnaire was developed by researchers, soliciting information on farming practices, agroforestry practices and knowledge and interest, educational needs, and personal background of the farmers. The questionnaire was tested on two farmers for its clarity, and minor modifications made.

Fifty-one farmers – comprising 45 men and six women – in the Água de Gato Watershed, selected by simple random sampling, were interviewed to determine their farming practices, their knowledge of and interest in agroforestry, and their personal backgrounds. All farmers who were contacted agreed to the interview. This sample represents nearly 29% of the farms in the watershed, which is considered the population in this study. All interviews were conducted by a native Cape Verdean, in Creole (the native language of the islands), with responses translated to Portuguese and then translated to English at the time of data entry. Interview schedules were arranged for their convenience, and interviews generally took about one hour to conduct. Farmers were informed that the purpose of the interview was to collect data to study possible agroforestry systems suitable for the watershed.

Statistical analyses were performed on the farmer characteristic data. Farmers were grouped according to their willingness to plant trees for three uses, namely fuelwood, fruit production and shade. For each group, a linear discriminant analysis model was developed, in which both continuous variables and categorical variables coded as dummy variables were used to classify farmers as willing or unwilling to plant trees for each purpose (Klecka 1980). A jack-knife procedure was used to assess the fit of the model to the sample data (Lachenbruch and Mickey 1968). In this procedure, each observation is withheld and tested to see if the model places it in the correct category. With a two-category system as adopted here (willing and unwilling), an observation has a 50% random chance of being correctly classified. Therefore, the fit of the model to the sample data can be judged by the increase in correct classification over 50%.

Discriminant analysis (as described for example by Klecka 1980) has been used in forestry applications for many years. It is used when the dependent variable is a classification variable, representing two or more groups. Independent discriminator variables are selected based on their ability to distinguish between groups and contribute to cohesiveness within groups. The Statistical Analysis System (SAS) was used for discriminant analysis in this study.

RESULTS AND DISCUSSION

Farmers in the Água de Gato Watershed were generally favourably disposed to incorporating more trees into their farming practices. Ninety-two percent of the farmers surveyed expressed a willingness to plant more trees, primarily for fruit production (73%), fuelwood (53%), and shade (16%) (Johnson and Delgado 2003). Additionally, 8% of the farmers expressed a willingness to plant trees for fodder, and 4% were interested in timber trees (Johnson and Delgado 1997).

Tree Planting for Fruit Production

Tree fruits serve the dual purpose of providing food for the family and also a valuable cash crop that can be sold. It is not surprising that the incorporation of fruit-bearing trees into the farming system would be looked upon favourably by farmers. The primary fruit trees grown in the Água de Gato Watershed include mango, avocado (*Persea americana*), lemon (*Citrus limonia*), orange (*Citrus sinensis*), papaya (*Carica papaya*) and coconut (*Cocus nucifera*). The discriminant analysis coefficients (Table 1) and correct classifications (Table 2) provide a means to evaluate farm and farmer characteristics and their relationship to the willingness groups. Age, gender, marital status and family size all had similar coefficients for the two willingness groups; however, males were more willing to plant fruit trees than females. Since fruits represent a cash crop, and men typically control the finances of the farm in this region, men would be more likely to be interested in selling fruits for cash. Franzel and Scherr (2002) noted that agroforestry adoption for farms headed by women often lags behind that of farms headed by men, because they tend to be more resource-limited, and extension services generally target more men than women. The potential financial returns from the sale of fruit may be a stronger motivating factor for men to plant fruit trees.

Other differences between the willingness groups included farm size; farmers willing to plant fruit had slightly larger farms, and smaller amounts of land farmed in partnerships. A concern with partnerships would be that the proceeds from the sale of the fruit would be split with the partner, leading to a reluctance to enter into a long-term arrangement like growing fruit trees. Although the sale of fruits would be a strong incentive for farmers to engage in more growing of fruit trees, farmers were generally unaware of the market potential for such crops, because currently most fruits are consumed within the watershed. Markets within the watershed are lacking. The development of marketing strategies for selling the products of agroforestry enterprises would be essential for it to make a substantial difference in income in the watershed. Russell and Franzel (2004) noted the importance of marketing to the ultimate success of agroforestry enterprises in Africa.

Farmers also perceived a trade-off between planting trees for shade and for fruit. Those farmers who were unwilling to plant trees for shade were far more willing to plant trees for fruit. Since fruit trees also provide some measure of shade, they are seen as dual-purpose trees. The discriminant analysis models correctly predicted 79% of the unwilling farmers and 73% of the willing farmers (Table 2), indicating strong relationships between willingness to plant and the independent variables.

Table 1. Linear discriminant analysis functions for three dependent variable groups describing willingness of farmers to plant more trees for fruit production, fuelwood and shade

Independent variable	Fruit		Fuelwood		Shade	
	No	Yes	No	Yes	No	Yes
Constant	-15.651	-16.430	-16.380	-18.241	-16.831	-18.116
X1 = Age (yr)	0.195	0.158	0.195	0.186	0.195	0.167
X2 = Gender[1]	14.383	12.276	14.383	16.112	14.383	13.995
X3 = Marital status[1]	11.880	14.276	11.880	12.124	11.880	14.576
X4 = Family size	0.880	0.991	0.880	0.871	0.880	0.803
X5 = Farm area owned (ha)	- 0.474	0.009	- 0.474	-0.639	-0.474	-0.241
X6 = Area farmed in partnership (ha)	-1.681	- 2.427	-1.681	-1.531	-1.681	-1.437
X7 = Farm area rented from others (ha)	-1.536	- 0.968	-1.536	-1.745	-1.536	- 0.851
X8 = Willingness to plant fruit trees[1]	---	---	3.653	5.109	3.653	1.595
X9 = Willingness to plant fuelwood trees[1]	0.853	2.309	---	---	0.853	4.013
X10 = Willingness to plant shade trees[1]	1.233	- 0.825	1.233	4.393	---	---
X11 = Currently growing fruit trees[1]	5.273	4.293	5.273	6.252	5.273	3.945

[1] X2: 0 = male, 1 = female; X3: 0 = unmarried, 1 = married; X8 to X11: 0 = no; 1 = yes.

Table 2. Linear discriminant analysis correct classifications for three dependent variable groups describing willingness of farmers to plant more trees for fruit production, fuelwood and shade

Classification	Fruit		Fuelwood		Shade	
	No	Yes	No	Yes	No	Yes
Predicted 'No'	11	10	21	10	32	2
Predicted 'Yes'	3	27	3	17	11	6
Total number	14	37	24	27	43	8
Number correct	11	27	21	17	332	6
Percentage classified correctly	79	73	88	63	74	75

Tree Planting for Fuelwood

Fuelwood was the second most favoured reason for planting more trees on farms (Figure 1). In the Água de Gato Watershed fuelwood is the main source of energy used for cooking, and is a scarce resource. The primary species used for fuelwood include mesquite (*Prosopis juliflora*), lantana (*Lantana camera*), maguey (*Furcraea foetida*), eucalypts, and giant reed grass (*Arundo donax*). The discriminant analysis coefficients (Table 1) allow a comparison between the two willingness groups for planting trees for fuelwood. Interestingly, women were more willing than men to plant trees for fuelwood. In this region, women have the responsibility of collecting fuelwood, often travelling great distances to scavenge enough for daily needs. Having a ready supply of fuel close to the farm would be a huge benefit.

Figure 1. Neem trees (*Azadirachta indica*) planted for fuelwood and shade in the Água de Gato Watershed, Santiago, Cape Verde

The other variable associated with the willingness groupings was willingness to plant shade trees (Table 1). While the willingness of farmers to plant shade trees was not high (16%), all eight farmers who were willing also wished to plant trees for fuelwood. While the reason is not immediately obvious, it may be that the farmers are also looking at the dual purpose of these trees – they may serve as shade producers, but also provide branches for fuel, and eventually may be harvested for fuel. In the watershed it was not unusual to see yard trees harvested for fuel. The correct classification results for the fuelwood discriminant analysis models are reported in Table 2. Eighty-eight percent of the unwilling farmers were correctly

classified, while 63% of the willing farmers were correctly classified. Again, this indicates a relatively strong fit within the discriminant analysis models.

Tree Planting for Shade

Of the three primary tree uses, shade had the lowest priority among farmers in the Água de Gato Watershed, with 16% expressing this willingness. For the most part, farmers were concerned with space for the trees and competition for light and water with planted crops. Also, most of the farms already had some shade trees around the house and barns, and there was little opportunity or need to add more. Commonly planted shade trees included tamarind (*Tamarindus indica*), mahogany, eucalypts, Egyptian thorn (*Acacia nilotica*) and beefwood (*Casuarina equisetifolia*).

   Of the discriminating variables (Table 1), the difference between coefficients stands out for gender. Only one of the six women surveyed indicated a willingness to plant shade trees. The strongest discriminating variable was the willingness to plant fuelwood trees. All of the farmers who were unwilling to plant fuelwood trees were also unwilling to plant shade trees. Of the 27 farmers who were willing to plant fuelwood trees, only eight were willing to plant shade trees. Basically, if concerns with cost and space were driving the tree planting decision, then the comfort value associated with shade was certainly not sufficient for farmers to make this investment. Again, the farmers who expressed a willingness to plant both fuelwood and shade trees were doing so for the dual benefits of shade and fuel.

CONCLUSIONS

Survey research in the Água de Gato Watershed reveals that farmers were overall quite willing to consider the planting of trees on their farms, for multiple uses. Ninety-two percent of the surveyed farmers expressed a willingness to plant trees, and the other 8% indicated they were unsure. None of the farmers surveyed said they definitely would not consider planting more trees. But serious constraints to adoption were also identified by the farmers, and overcoming these constraints would be critical to making the move from willingness (an expression of adoption potential) to actual adoption. The implication is that in the Água de Gato Watershed, agroforestry system development should focus on the incorporation of trees for fruit and fuelwood, and to a lesser extent on shade trees for human and animal comfort. Demonstrations and on-farm research (Scherr and Franzel 2002) would be crucial to demonstrating the best species and system opportunities. Policy questions and legal issues such as ownership of the trees and fruits, especially in cases where the land is rented or farmed in partnership, would need to be resolved, and for the potential economic gains envisioned, market development work would be needed (Muok *et al*. 1998, Franzel and Scherr 2002, Russell and Franzel 2004).

   This research identified a suite of continuous and discrete variables that, collectively, were effective at discerning the willingness groups. Percent correct classifications ranged from 63% to 88%, and averaged 75%. However, these variables express willingness only, based on the current knowledge of the farmers. Technical assistance providers, including extensionists, could take this information and design cost-effective extension programs to move the farmers closer toward adoption. For example, since twice as many women indicated a willingness to plant

trees for fuelwood as did not, extension programs focused on women may lead to greater adoption. Men tended to prefer tree planting for fruit production, and larger farms were more receptive. When seeking the early adopters for agroforestry practices, knowing the characteristics that underlie willing participants is critical.

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